Magnetic Gear

Website link: http://www.infolytica.com/en/coolstuff/ex0106/

Magnomatics Limited

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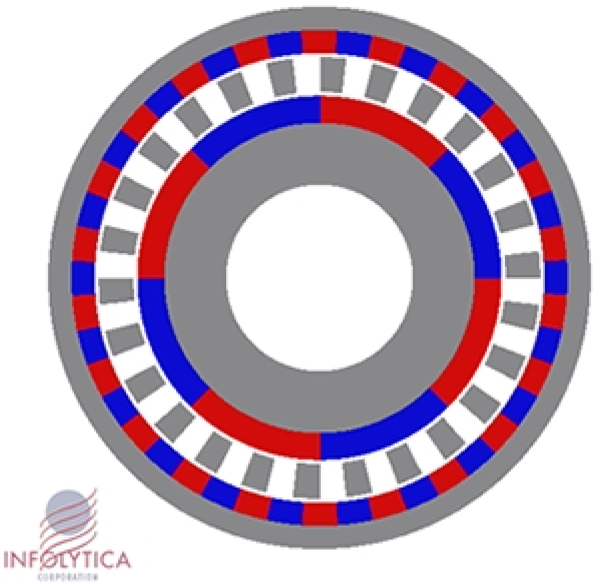
Contactless, high-efficiency, high-torque transmission with inherent overload protection

The high-torque magnetic gear was invented and demonstrated by Magnomatics co-founder Dr Kais Atallah in 2001. This pioneering research has been extended by Magnomatics to provide a mature range of gear technologies that are suitable for a very wide range of applications. A torque density in excess of 70 kN m/m^3 can be achieved.

Advantages over mechanical gears

- Reduced maintenance and improved reliability
- Lubrication free
- Higher efficiency than conventional gears
- Precise peak torque transmission (up to 665 Nm of torque per meter of length of the gears) and inherent overload protection
- Physical isolation between input and output shafts
- Inherent anti-jamming transmission
- Significantly reduces harmful drivetrain pulsations
- Allows for misalignment/vibration of shafts
- Very low acoustic noise and vibration

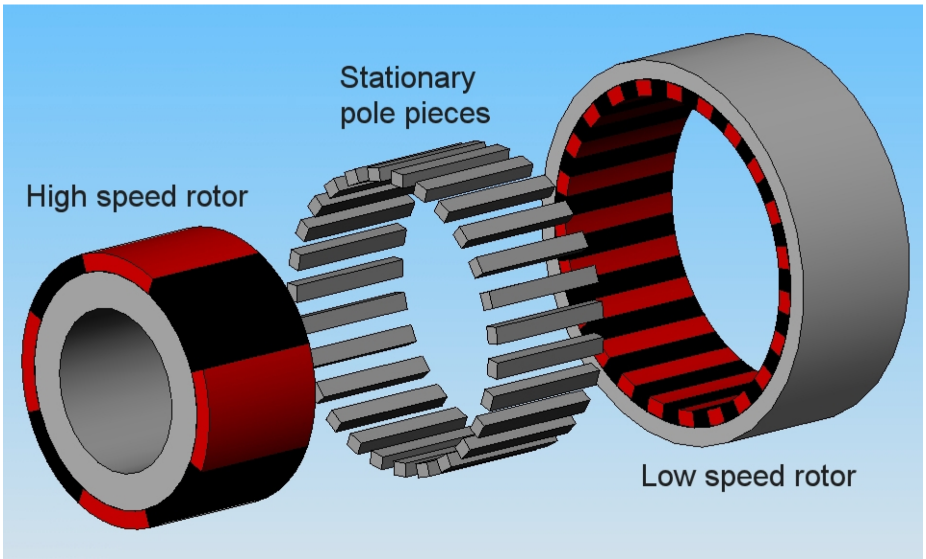


A magnetic gear uses permanent magnets to transmit torque between an input and output shaft without mechanical contact. Torque densities comparable with mechanical gears can be achieved with an efficiency >99% at full load and with much higher part load efficiencies than a mechanical gear. For higher power ratings a magnetic gear will be smaller, lighter and lower cost than a mechanical gear. Since there is no mechanical contact between the moving parts there is no wear and lubrication is not required. Magnetic gears inherently protect against overloads by harmlessly slipping if an overload torque is applied, and automatically and safely re-engaging when the fault torque is removed.

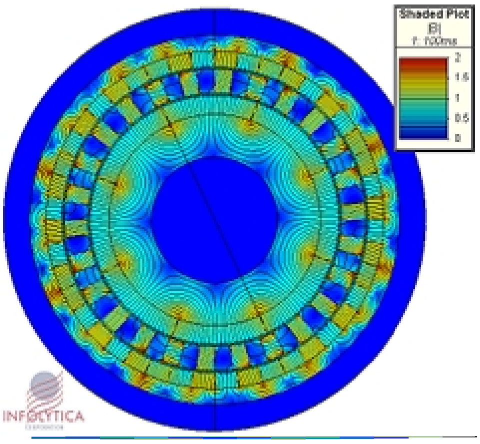
Magnomatics has developed a range of magnetic gear technologies for achieving low and high ratios and a linear gear variant. The magnetic gear concept has been extended to provide both an ultra high torque density pseudo direct drive electrical machine and a variable ratio gear topology for continuously variable transmission systems.

Recently, a new type of magnetic gear has been proposed by Kais Atallah and Dave Howe in ***IEEE Transactions on Magnetics, Vol. 37, No. 4, pp. 2844***-2846, July 2001. While it is still in the theoretical stage, the simulations presented here confirm that it has the potential to replace conventional mechanical gearboxes in some applications. This example also highlights the advanced capabilities of Infolytica's ***Transient with Motion solver***, which is able to simulate multiple moving parts simultaneously.

The operation of this gear assembly is analogous to a Planetary Gear assembly, with the inner rotor acting as the sun gear, the outer rotor as the ring gear, and the stationary steel pole pieces acting as planetary gears (it is the magnetic field that spins, not the pole pieces themselves). Since there are 44 magnets in the outer rotor and 8 in the inner rotor, the gear ratio of this magnetic gearbox is 5.5:1.

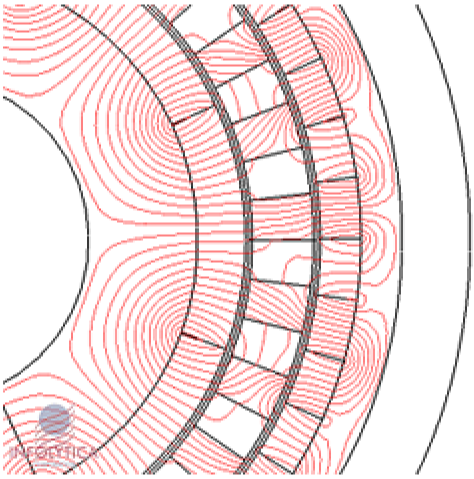


Results



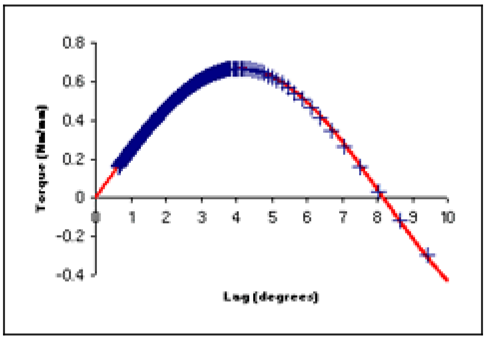
This animation displays the flux lines and the shaded plot of the magnetic flux density as the gears come up to speed. At the end of this simulation, the inner rotor is being driven at a constant speed of 833 rpm. The outer rotor is load driven, with a viscous friction applied, and its rotational speed is calculated by MagNet to be -151.5 rpm.

- [Video] - AVI clip - 9012KB



The operation of the gears can be seen from this animation of the flux lines, which shows the magnetic field in the pole pieces rotating as the rotors turn. **The outer rotor rotates in the opposite direction to the inner rotor**, and the field in the pole piece completes one revolution as each pair of rotor and stator magnets pass by it.

- [Video] - AVI clip - 3120KB



The torque transmission capability is evaluated with another simulation that runs the inner rotor at constant speed, while gradually increasing the load on the outer rotor. When the load exceeds the torque limit of the magnetic gears, the outer rotor starts to slip. Before this point, the outer rotor will lag the inner rotor and, in fact, the relation between torque and lag is approximately sinusoidal, with a period equal to twice the rotor magnet spacing (360/22 degrees). This graph shows that this set of gears is capable of transmitting up to 665 Nm of torque per meter of length of the gears.

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